Chapter

11

COST OF TREATMENT TECHNOLOGIES

This chapter explains what EPA has estimated it will cost to comply with the CWT effluent limitations guidelines and standards. Section 11.1 provides a general description of how EPA developed costs for the different individual treatment technology and regulatory option considered for this rule. Sections 11.2 through 11.4 describe the development of costs for each of the wastewater and sludge treatment technologies evaluated.

Section 11.5 describes additional compliance costs not related to a specific technology that a facility may incur. These additional items are retrofit costs, monitoring costs, RCRA permit modification costs, and land costs.

In Section 11.6, EPA presents some examples of capital and O&M cost calculations for CWT facilities using this methodology. Finally, Section 11.7 summarizes, by subcategory, the total capital expenditures and annual O&M costs for implementing the regulation. Appendix D contains, by subcategory, the facility-specific capital, O&M, land, RCRA, and monitoring cost estimates for each facility to comply with the limitations and standards.

COSTS DEVELOPMENT — *11.1*

Technology Costs — *11.1.1*

EPA obtained cost information for the technologies that it considered in developing the limitations guidelines and standards from the following sources:

- The data base developed from the information provided in response to the 1991 Waste Treatment Industry (WTI) Questionnaire (this contained some process cost information, and EPA used this wherever possible);
- Technical information developed for other rulemaking such as the guidelines and standards for the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) category, Metal Products and Machinery (MP&M) category, and Industrial Laundries industries category;
- Engineering literature;
- Data obtained in sampling at the CWT model facilities; and
- Cost quotations obtained from vendors (EPA used these extensively in estimating the cost of the various technologies).

The total costs developed by EPA include the following elements: capital costs of investment in pollutant control equipment, annual O&M costs, land requirement costs, sludge disposal costs, monitoring costs, and retrofit costs. Because 1989 is the base year for the WTI Questionnaire, EPA scaled all of the costs either up or down to 1989 dollars using the Engineering News Record (ENR) Construction Cost Index. EPA uses a 1989 base year to facilitate comparison from guideline to guideline.

EPA based the capital costs for the technologies primarily on cost quotations from vendors. Table 11-1 lists the standard factors used to estimate the capital costs. Equipment costs typically include the cost of the treatment unit and some ancillary equipment associated with that technology. Other investment costs in addition to the equipment cost include piping, instrumentation and controls, pumps, installation, engineering, delivery, and contingency.

EPA estimated certain design parameters for costing purposes. One such parameter is the flow rate used to size many of the treatment technologies. EPA used the total daily flow in all cases, unless specifically stated. The total daily flow represents the annual flow divided by 260, the standard number of operating days for a CWT per year.

EPA derived the annual O&M costs for the various systems from vendors' information or from engineering literature, unless otherwise stated. The annual O&M costs represent the costs of maintenance, taxes and insurance, labor, energy, treatment chemicals (if needed), and residuals management (also if needed). Table 11-2 lists the standard factors EPA used to estimate the O&M costs.

Sections 11.2 through 11.4 present cost equations for capital costs, O&M costs, and land requirements for each technology and option. For most technologies, EPA also developed capital cost upgrade and O&M cost upgrade equations. EPA used these equations for facilities which already have the treatment technology forming the basis of the option (or some portion of the treatment technology) in place. EPA also presents the flow rate ranges recommended for use in each equation. EPA is confident the equations are representative of costs for such facilities within these ranges. Outside these ranges, the equations become extrapolations. These equations, in EPA's views, do not yield reliable results below the recommended low flow rate.

Table 11-1. Standard Capital Cost Algorithm

Factor	Capital Cost
Equipment Cost	Technology-Specific Cost
Installation	25 to 55 percent of Equipment Cost
Piping	31 to 66 percent of Equipment Cost
Instrumentation and Controls	6 to 30 percent of Equipment Cost
Total Construction Cost	Equipment + Installation + Piping + Instrumentation and Controls
Engineering	15 percent of Total Construction Cost
Contingency	15 percent of Total Construction Cost
Total Indirect Cost	Engineering + Contingency
Total Capital Cost	Total Construction Cost + Total Indirect Cost

Option Costs *11.1.2*

EPA developed engineering costs for each of the individual treatment technologies which EPA considered in developing the CWT limitations guidelines and standards. This chapter breaks down these technology-specific costs into capital, O&M, and land components. To estimate the cost of any individual regulatory option EPA considered for this guideline, it is necessary to sum the costs of the individual treatment technologies which make up that option. In a few instances, an option consists of only one treatment technology. In those instances, the option cost is obviously equal to the technology cost. Table 11-3 shows the CWT subcategory technology options EPA considered. The table lists the treatment technologies included in each option, and indicates the subsections which provide the corresponding cost information.

EPA generally calculated the capital and O&M costs for each of the individual treatment technologies using a flow rate range of 1 gallon per day to five million gallons per day. However, the flow rate ranges recommended for use in the equations are in a smaller range. Sections 11.2 to 11.4 present these ranges for each cost equation.

Land Requirements and Costs 11.1.2.1

EPA calculated land requirements for each piece of new equipment based on the equipment dimensions. The land requirements include the total area needed for the equipment plus peripherals (pumps, controls, access areas, etc.). Additionally, EPA included a 20-foot perimeter around each unit. In the cases where adjacent tanks or pieces of equipment were required, EPA used a 20-foot perimeter for each piece of equipment, and used the minimum area requirements possible. The tables throughout Sections 11.2 to 11.4 present the land requirement equations for each technology. EPA then multiplied the land requirements by the corresponding land costs (as detailed in 11.5.4) to obtain facility specific land cost estimates.

Table 11-2. Standard Operation and Maintenance Cost Factor Breakdown

Factor	O&M Cost (1989 $/year)
Maintenance	4 percent of Total Capital Cost
Taxes and Insurance	2 percent of Total Capital Cost
Labor	$30,300 to $31,200 per man-year
Electricity	$0.08 per kilowatt-hour
Chemicals:	
Lime (Calcium Hydroxide)	$57 per ton
Polymer	$3.38 per pound
Sodium Hydroxide (100 percent solution)	$560 per ton
Sodium Hydroxide (50 percent solution)	$275 per ton
Sodium Hypochlorite	$0.64 per pound
Sulfuric Acid	$80 per ton
Aries Tek Ltd Cationic Polymer	$1.34 per pound
Ferrous Sulfate	$0.09 per pound
Hydrated Lime	$0.04 per pound
Sodium Sulfide	$0.30 per pound
Residuals Management	Technology-Specific Cost
Total O&M Cost	Maintenance + Taxes and Insurance + Labor + Electricity + Chemicals + Residuals

Operation and Maintenance Costs 11.1.2.2

EPA based O&M costs on estimated energy usage, maintenance, labor, taxes and insurance, and chemical usage cost. With the principal exception of chemical usage and labor costs, EPA calculated the O&M costs using a single methodology. This methodology is relatively consistent for each treatment technology, unless specifically noted otherwise.

EPA's energy usage costs include electricity, lighting, and controls. EPA estimated electricity requirements at 0.5 Kwhr per 1,000 gallons of wastewater treated. EPA assumed lighting and controls to cost $1,000 per year and electricity cost $0.08 per Kwhr. Manufacturers' recommendations form the basis of these estimates.

EPA based maintenance, taxes, and insurance on a percentage of the total capital cost as detailed in Table 11-2.

Chemical usage and labor requirements are technology specific. These costs are detailed for each specific technology according to the index given in Table 11-3.

Table 11-3. CWT Treatment Technology Costing Index – A Guide to the Costing Methodology Sections

Subcategory/ Option	Treatment Technology	Section
Metals 2	Selective Metals Precipitation	11.2.1.1
	Plate and Frame Liquid Filtration	11.2.2.1
	Secondary Chemical Precipitation	11.2.1.2
	Clarification	11.2.2.2
	Plate and Frame Sludge Filtration	11.4.1
	Filter Cake Disposal	11.4.2
Metals 3	Selective Metals Precipitation	11.2.1.1
	Plate and Frame Liquid Filtration	11.2.2.1
	Secondary Chemical Precipitation	11.2.1.2
	Clarification	11.2.2.2
	Tertiary Chemical Precipitation and pH Adjustment	11.2.1.3
	Clarification	11.2.2.2
	Plate and Frame Sludge Filtration	11.4.1
	Filter Cake Disposal	11.4.2
Metals 4	Primary Chemical Precipitation	11.2.1.4
	Clarification	11.2.2.2
	Secondary (Sulfide) Chemical Precipitation	11.2.1.5
	Secondary Clarification (for Direct Dischargers Only)	11.2.2.2
	Multi-Media Filtration	11.2.5
	Plate and Frame Sludge Filtration[1]	11.4.1
Metals - Cyanide Waste Pretreatment	Cyanide Destruction at Special Operating Conditions	11.2.6
Oils 8	Dissolved Air Flotation	11.2.8
Oils 8v	Dissolved Air Flotation	11.2.8
	Air Stripping	11.2.4
Oils 9	Secondary Gravity Separation	11.2.7
	Dissolved Air Flotation	11.2.8
Oils 9v	Secondary Gravity Separation	11.2.7
	Dissolved Air Flotation	11.2.8
	Air Stripping	11.2.4
Organics 4	Equalization	11.2.3
	Sequencing Batch Reactor	11.3.1
Organics 3	Equalization	11.2.3
	Sequencing Batch Reactor	11.3.1
	Air Stripping	11.2.4

[1]Metals option 4 sludge filtration includes filter cake disposal.

PHYSICAL/CHEMICAL WASTEWATER TREATMENT TECHNOLOGY COSTS 11.2

Chemical Precipitation 11.2.1

Wastewater treatment facilities widely use chemical precipitation systems to remove dissolved metals from wastewater. EPA evaluated systems that utilize sulfide, lime, and caustic as the precipitants because of their common use in CWT chemical precipitation systems and their effectiveness in removing dissolved metals.

Selective Metals Precipitation – Metals Options 2 and 3 11.2.1.1

Among the technologies EPA evaluated for treating metal-bearing wastestreams were systems that "selectively" removed metals. These are systems designed to address the fact that different metals are more efficiently removed at different pHs. These systems perform a series of precipitations at different pHs in order to maximize removals. The selective metals precipitation equipment assumed by EPA for costing purposes for Metals option 2 and Metals option 3 consists of four mixed reaction tanks, each sized for 25 percent of the total daily flow, with pumps and treatment chemical feed systems. EPA costed for four reaction tanks to allow a facility to segregate its wastes into small batches, thereby facilitating metals recovery and avoiding interference with other incoming waste receipts. EPA assumed that these four tanks would provide adequate surge and equalization capacity for a metals subcategory CWT. EPA based costs on a four batch per day treatment schedule (that is, the sum of four batch volumes equals the facility's daily incoming waste volume).

As shown in Table 11-3, plate and frame liquid filtration follows selective metals precipitation for Metals options 2 and 3. EPA has not presented the costing discussion for plate and frame liquid filtration in this section (consult section 11.2.3.2). Likewise, Sections 11.4.1 and 11.4.2 discuss sludge filtration and filter cake disposal.

CAPITAL COSTS

Because only one facility in the metals subcategory has selective metals precipitation in-place, EPA included selected metals precipitation capital costs for all facilities (except one) for Metals options 2 and 3.

EPA obtained the equipment capital cost estimates for the selective metals precipitation systems from vendor quotations. These costs include the cost of the mixed reaction tanks with pumps and treatment chemical feed systems. The total construction cost estimates include installation, piping and instrumentation, and controls. The total capital cost includes engineering and contingency at a percentage of the total construction cost plus the total construction cost (as explained in Table 11-1). Table 11-4 at the end of this section presents the equation for calculating selective metals precipitation capital costs for Metals option 2 and option 3.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

EPA based the labor requirements for selective metals precipitation on the model facility's operation. EPA estimated the labor cost at eight man-hours per batch (four treatment tanks per batch, two hours per treatment tank per batch).

EPA estimated selective metals precipitation chemical costs based on stoichiometric, pH adjustment, and buffer adjustment requirements. For facilities with no form of chemical precipitation in-place, EPA based the stoichiometric requirements on the amount of chemicals required to precipitate each of the metal and semi-metal pollutants of concern from the metals subcategory average raw influent concentrations to current performance levels (see Chapter 12 for a discussion of raw influent concentrations and current loadings). The chemicals used were caustic at 40 percent of the required removals and lime at 60 percent of the required removals (caustic at 40 percent and lime at 60 percent add up to 100 percent of the stoichiometric requirements.) These chemical dosages reflect the operation of the selective metals precipitation model facility. Selective metals precipitation uses a relatively high percentage of caustic because the sludge resulting from caustic precipitation is amenable to metals recovery. EPA estimated the pH adjustment and buffer adjustment requirements to be 40 percent of the stoichiometric requirement. EPA added an excess of 10 percent to the pH and buffer adjustment requirements, bringing the total to 50 percent. EPA included a 10 percent excess because this is typical of the operation of the CWT facilities visited and sampled by EPA.

EPA estimated selective metals precipitation upgrade costs for facilities that currently utilize some form of chemical precipitation. Based on responses to the Waste Treatment Industry Questionnaire, EPA assumed that the in-place chemical precipitation systems use a dosage ratio of 25% caustic and 75% lime and achieve a reduction of pollutants from "raw" to "current" levels. The selective metals precipitation upgrade would require a change in the existing dosage mix to 40% caustic and 60 % lime. Therefore, the selective metals precipitation upgrade for facilities with in-place chemical precipitation is the increase in caustic cost (from 25 % to 40%) minus the lime credit (to decrease from 75% to 60%).

Table 11-4 presents the O&M cost equation for selective metals precipitation along with the O&M upgrade cost equation for facilities with primary and secondary chemical precipitation in-place.

Table 11-4. Cost Equations for *Selective Metals Precipitation* in Metals Options 2 and 3

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost	$\ln(Y1) = 14.461 + 0.544\ln(X) + 0.0000047(\ln(X))^2$	1.0 E -6 to 5.0
O&M cost for facilities without chem. precipitation treatment in-place	$\ln(Y2) = 15.6402 + 1.001\ln(X) + 0.04857(\ln(X))^2$	3.4 E -5 to 5.0
O&M *upgrade* cost for facilities with precipitation in-place	$\ln(Y2) = 14.2545 + 0.8066\ln(X) + 0.04214(\ln(X))^2$	7.4 E -5 to 5.0
Land requirements	$\ln(Y3) = -0.575 + 0.420\ln(X) + 0.025(\ln(X))^2$	1.6 E -2 to 4.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Secondary Precipitation – Metals Options 2 and 3 *11.2.1.2*

The secondary precipitation system in the model technology for Metals option 2 and Metals option 3 follows selective metals precipitation and plate and frame liquid filtration. This secondary chemical precipitation equipment consists of a single mixed reaction tank with pumps and a treatment chemical feed system, which is sized for the full daily batch volume.

As shown in Table 11-3, clarification follows secondary chemical precipitation for Metals options 2 and 3. Section 11.2.2.2 discusses the costing for clarification following secondary precipitation. Sections 11.4.1 and 11.4.2 discuss sludge filtration and the associated filter cake disposal.

Many facilities in the metals subcategory currently have chemical precipitation units in-place. For these facilities, cost upgrades may be appropriate. EPA used the following set of rules to decide whether a facility's costs should be based on a full cost equation or an upgrade equation for the secondary chemical precipitation step of metals options 2 and 3:

- Facilities with no chemical precipitation in-place should use the full capital and O&M costs;
- Facilities with primary chemical precipitation in-place should assume no capital costs, no land requirements, but an O&M upgrade cost for the primary step; and
- Facilities with secondary chemical precipitation currently in-place should assume no capital costs, no land requirements, and no O&M costs for the secondary step.

Capital Costs

For facilities that have no chemical precipitation in-place, EPA calculated capital cost estimates for the secondary precipitation treatment systems from vendor quotations.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 11.2.1.1 above). Table 11-5 at the end of this section shows the capital cost equation for secondary precipitation in Metals option 2 and option 3.

For the facilities that have at least primary chemical precipitation in-place, EPA assumed that the capital cost for the secondary precipitation treatment system would be zero. The in-place primary chemical precipitation systems would serve as secondary precipitation systems after the installation of upstream selective metals precipitation units.

Chemical Usage and Labor Requirement Costs

EPA developed O&M cost estimates for the secondary precipitation step of Metals option 2 and 3 for facilities with and without chemical precipitation currently in-place. For facilities with no chemical precipitation in-place, EPA calculated the amount of lime required to precipitate each of the metals and semi-metals from the metals subcategory current performance concentrations (achieved with the previously explained selective metals precipitation step) to the Metals option 2 long-term average concentrations. EPA then added a ten percent excess dosage factor and based the chemical addition costs on the required amount of lime only, which is based on the operation of the model facility for this technology. EPA assumed the labor cost to be two hours per batch, based on recommendations from manufacturers.

For facilities with chemical precipitation in-place, EPA calculated an O&M upgrade cost. In calculating the O&M upgrade cost, EPA assumed that there would be no additional costs associated with any of the components of the annual O&M cost, except for increased chemical costs.

Because EPA already applied credit for chemical costs for facilities with primary precipitation in estimating the selective metals precipitation chemical costs, the chemical upgrade costs for facilities with primary precipitation are identical to facilities with no chemical precipitation in-place.

Because EPA assumed that facilities with secondary precipitation would achieve the metals option 2 long term average concentrations with their current system and chemical additions (after installing the selective metals precipitation system), EPA assumed these facilities would not incur any additional chemical costs. In turn, EPA also assumed that facilities with secondary precipitation units in-place would incur no O&M upgrade costs.

Table 11-5. Cost Equations for *Secondary Chemical Precipitation* in Metals Options 2 and 3

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost	$\ln(Y1) = 13.829 + 0.544\ln(X) + 0.00000496(\ln(X))^2$	1.0 E -6 to 5.0
O&M cost for facilities with no chemical precipitation in-place	$\ln(Y2) = 11.6553 + 0.48348\ln(X) + 0.02485(\ln(X))^2$	6.5 E -5 to 5.0
O&M *upgrade* cost for facilities with primary precipitation in-place	$\ln(Y2) = 9.97021 + 1.00162\ln(X) + 0.00037(\ln(X))^2$	5.0 E -4 to 5.0
Land requirements	$\ln(Y3) = -1.15 + 0.449\ln(X) + 0.027(\ln(X))^2$	4.0 E -3 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Tertiary Precipitation and pH Adjustment – Metals Option 3 *11.2.1.3*

The tertiary chemical precipitation step for Metals option 3 follows the secondary precipitation and clarification steps. This tertiary precipitation system consists of a rapid mix neutralization tank and a pH adjustment tank. In this step, the wastewater is fed to the rapid mix neutralization tank where lime slurry is added to raise the pH to 11.0. Effluent from the neutralization tank then flows to a clarifier for solids removal. The clarifier overflow goes to a pH adjustment tank where sulfuric acid is added to achieve the desired final pH of 9.0. This section explains the development of the cost estimates for the rapid mix neutralization tank and the pH adjustment tank. Sections 11.2.2.2, 11.4.1, and 11.4.2 discuss clarification, sludge filtration, and associated filter cake disposal.

CAPITAL COSTS

EPA developed the capital cost estimates for the rapid mix tank assuming continuous flow and a 15-minute detention time, which is based on the model facility's standard operation. The equipment cost includes one tank, one agitator, and one lime feed system.

EPA developed the capital cost estimates for the pH adjustment tank assuming continuous flow and a five-minute detention time, also based on the model facility's operation. The equipment cost includes one tank, one agitator, and one sulfuric acid feed system.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost for both the rapid mix and pH adjustment tank by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 11.2.1.1 above). Table 11-6 at the end of this section presents the capital cost equations for the rapid mix and pH adjustment tanks.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

EPA did not assign O&M costs, and in turn, chemical usage and labor requirement costs for tertiary precipitation and pH adjustment to the few facilities which have tertiary precipitation (and pH adjustment) systems in-place. For those facilities without tertiary precipitation (and pH adjustment) in-place, EPA estimated the labor requirements at one man-hour per day for the rapid mix and pH adjustment tanks. EPA based this estimate on the model facility's typical operation.

EPA estimated chemical costs for the rapid mix tank based on lime addition to achieve the stoichiometric requirements of reducing the metals in the wastewater from the Metals option 2 long-term averages to the Metals option 3 long-term averages, with a 10 percent excess. EPA estimated the chemical requirements for the pH adjustment tank based on the addition of sulfuric acid to lower the pH from 11.0 to 9.0, based on the model facility's operation. Table 11-6 the O&M cost equations for the rapid mix tank and pH adjustment tank.

Table 11-6. Cost Equations for *Tertiary Chemical Precipitation* in Metals Option 3

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for rapid mix tank	$\ln(Y1) = 12.318 + 0.543\ln(X) - 0.000179(\ln(X))^2$	1.0 E -5 to 5.0
Capital cost for pH adjustment tank	$\ln(Y1) = 11.721 + 0.543\ln(X) + 0.000139(\ln(X))^2$	1.0 E -5 to 5.0
O&M cost for rapid mix tank	$\ln(Y2) = 9.98761 + 0.37514\ln(X) + 0.02124(\ln(X))^2$	1.6 E -4 to 5.0
O&M cost for pH adjustment tank	$\ln(Y2) = 9.71626 + 0.33275\ln(X) + 0.0196(\ln(X))^2$	2.5 E -4 to 5.0
Land requirements for rapid mix tank	$\ln(Y3) = -2.330 + 0.352\ln(X) + 0.019(\ln(X))^2$	1.0 E -2 to 5.0
Land requirements for pH adjust. tank	$\ln(Y3) = -2.67 + 0.30\ln(X) + 0.033(\ln(X))^2$	1.0 E -2 to 5.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Primary Chemical Precipitation – Metals Option 4 *11.2.1.4*

The primary chemical precipitation system equipment for the model technology for Metals option 4 consists of a mixed reaction tank with pumps, a treatment chemical feed system, and an unmixed wastewater holding tank. EPA designed the system to operate on a batch basis, treating one batch per day, five days per week. The average chemical precipitation batch duration reported by respondents to the WTI Questionnaire was four hours. Therefore, a one batch per day treatment schedule should provide sufficient time for the average facility to pump, treat, and test its waste. EPA also included a holding tank, equal to the daily waste volume, up to a maximum size of 5,000 gallons (equivalent to the average tank truck receipt volume throughout the industry), to allow facilities flexibility in managing waste receipts (the Metals option 4 model facility utilizes a holding tank).

As shown in Table 11-3, clarification follows primary chemical precipitation for metals option 4. The costing discussion for clarification following primary precipitation in Metals option 4 is presented in section 11.2.2.2. Sections 11.4.1 and 11.4.2 discuss sludge filtration and the associated filter cake disposal.

CAPITAL COSTS

EPA developed total capital cost estimates for the Metals option 4 primary chemical precipitation systems. For facilities with no chemical precipitation units in-place, the components of the chemical precipitation system included a precipitation tank with a mixer, pumps, and a feed system. In addition, EPA included a holding tank equal to the size of the precipitation tank, up to 5,000 gallons. EPA obtained these cost estimates from manufacturer's recommendations.

EPA estimated the other components (i.e., piping, instrumentation and controls, etc.) of the total capital cost for both the rapid mix and pH adjustment tank by applying the same factors and additional costs as detailed for selective metals precipitation (see Section 11.2.1.1 above).

For facilities that already have any chemical precipitation (treatment in-place), EPA included as capital expense only the cost of a holding tank. Table 11-7 presents the capital cost equations for primary chemical precipitation and the holding tank only for Metals option 4.

LABOR AND CHEMICAL COSTS

EPA approximated the labor cost for primary chemical precipitation in Metals option 4 at two hours per batch, one batch per day. EPA based this approach on the model facility's operation.

EPA estimated chemical costs based on stoichiometric, pH adjustment, and buffer adjustment requirements. For facilities with no chemical precipitation in-place, EPA based the stoichiometric requirements on the amount of chemicals required to precipitate each of the metal pollutants of concern from the metals subcategory average raw influent concentrations to Metals option 4 (Sample Point - 03) concentrations. Metals option 4, Sample Point - 03 concentrations represent the sampled effluent from primary chemical precipitation at the model facility. The chemicals used were lime at 75 percent of the required removals and caustic at 25 percent of the required removals, which are based on the option facility's operation. EPA estimated the pH adjustment and buffer adjustment requirements to be 50 percent of the stoichiometric requirement, which includes a 10 percent excess of chemical dosage. Table 11-7 presents the O&M cost equation for primary chemical precipitation in Metals option 4 for facilities with no treatment in-place.

For facilities which already have chemical precipitation treatment in-place, EPA estimated an O&M upgrade cost. EPA assumed that facilities with primary chemical precipitation in-place have effluent concentrations exiting the primary precipitation/solid-liquids separation system equal to the metals subcategory primary precipitation current loadings. Similarly, EPA assumed that facilities with secondary chemical precipitation in place have effluent concentrations exiting the secondary precipitation/solid-liquids separation system equal to metals subcategory secondary precipitation current loadings (see chapter 12 for a detailed discussion of metals subcategory primary and secondary chemical precipitation current loadings).

For the portion of the O&M upgrade equation associated with energy, maintenance, and labor, EPA calculated the percentage difference between the primary precipitation current loadings and Metals option 4 (Sample Point - 03) concentrations. For facilities which currently have primary precipitation systems this difference is an increase of approximately two percent. Therefore, EPA calculated the energy, maintenance, and labor components of the O&M upgrade cost for facilities with primary chemical precipitation in-place at two percent of the O&M cost for facilities with no chemical precipitation in-place.

For the portion of the O&M upgrade equation associated with energy, maintenance, and labor, EPA calculated the percentage difference between secondary precipitation current loadings and Metals option 4 (Sample Point - 03) concentrations. For secondary precipitation systems, this difference is also an increase of approximately two percent[1]. Therefore, EPA calculated the energy, maintenance, and labor components of the O&M upgrade cost for facilities with secondary chemical precipitation in-place at two percent of the O&M cost for facilities with no chemical precipitation in-place.

For the chemical cost portion of the O&M upgrade, EPA also calculated upgrade costs depending on whether the facility had primary precipitation or secondary precipitation currently in-place. For facilities with primary precipitation, EPA calculated chemical upgrade costs based on current-to-Metals option 4 (Sample Point - 03) removals. Similarly for facilities with secondary precipitation, EPA calculated chemical upgrade costs based on secondary precipitation removals to Metals option 4 (Sample Point - 03) removals. In both cases, EPA did not include costs for pH adjustment or buffering chemicals since these chemicals should already be used in the in-place treatment system. Finally, EPA included a 10 percent excess of chemical dosage to the stoichiometric requirements of the precipitation chemicals.

EPA then combined the energy, maintenance and labor components of the O&M upgrade with the chemical portion of the O&M upgrade to develop two sets of O&M upgrade equations for the primary chemical precipitation portion of Metals option 4. Table 11-7 presents these cost equations for Metals option 4 (primary chemical precipitation O&M upgrade costs) for facilities with primary and secondary treatment in place.

[1] While pollutant concentrations resulting from secondary chemical precipitation are generally lower than those resulting from primary chemical precipitation, the percentage increase (when rounded) for primary and secondary precipitation are the same.

Table 11-7. Cost Equations for *Primary Chemical Precipitation* in Metals Option 4

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for primary precipitation and no treatment in-place	$\ln(Y1) = 14.019 + 0.481\ln(X) - 0.00307(\ln(X))^2$	1.0 E -6 to 5.0
Capital cost for holding tank only - used for facilities with chemical precipitation currently in-place.	$\ln(Y1) = 10.671 - 0.083\ln(X) - 0.032(\ln(X))^2$	1.0 E -6 to 0.005
O&M cost for primary precipitation and no treatment in-place	$\ln(Y2) = 15.3534 + 1.08700\ln(X) + 0.04891(\ln(X))^2$	1.7 E -5 to 5.0
O&M *upgrade* for facilities with primary precipitation in-place	$\ln(Y2) = 11.6203 + 1.05998\ln(X) + 0.04602(\ln(X))^2$	2.0 E -5 to 5.0
O&M *upgrade* for facilities with secondary precipitation in-place	$\ln(Y3) = 10.9500 + 0.94821\ln(X) + 0.04306(\ln(X))^2$	1.7 E -5 to 5.0
Land requirements	$\ln(Y3) = -1.019 + 0.299\ln(X) + 0.015(\ln(X))^2$	6.7 E -5 to 1.0
Land requirements (associated with holding tank only)	$\ln(Y3) = -2.866 - 0.023\ln(X) - 0.006(\ln(X))^2$	1.0 E -5 to 0.5

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Secondary (Sulfide) Precipitation for Metals Option 4 *11.2.1.5*

The Metals option 4 secondary sulfide precipitation system follows the primary metals precipitation/clarification step. This equipment consists of a mixed reaction tank with pumps and a treatment chemical feed system, sized for the full daily batch volume. For direct dischargers, the overflow from secondary sulfide precipitation would carry on to a clarifier and then multi-media filtration. For indirect discharges, the overflow would go immediately to the filtration unit, without clarification. Section 11.2.2.2 of this document discusses cost estimates for the clarifier. Section 11.2.5 presents cost estimates for multi-media filtration.

For costing purposes, EPA assumed that facilities either have secondary precipitation currently in-place and attributes no additional capital and O&M costs to these facilities, or EPA assumes that facilities do not have secondary sulfide precipitation in-place and, consequently, EPA developed costs for full O&M and capital costs. Therefore, EPA has not developed upgrade costs associated with secondary precipitation in Metals option 4.

CAPITAL COSTS

EPA developed capital cost estimates for the secondary sulfide precipitation systems in Metals option 4 from vendor's quotes. EPA estimated the other components (i.e., piping, instrumentation, and controls, etc.) of the sulfide precipitation system by applying the same methodology, factors and additional costs as outlined for the primary chemical precipitation system for Metals option 4 (see Section 11.2.1.4 above). Table 11-8 at the end of this section presents the capital cost equation for Metals option 4 secondary sulfide precipitation.

LABOR AND CHEMICAL COSTS

For facilities with no secondary precipitation systems in-place, EPA estimated the labor requirements at two hours per batch, one batch per day. EPA based this estimate on standard operation at the Metals option 4 model facility.

For secondary sulfide precipitation in Metals option 4, EPA did not base the chemical cost estimates on stoichiometric requirements. Instead, EPA estimated the chemical costs based on dosage rates for the addition of polymer and ferrous sulfide obtained during the sampling of the Metals option 4 model plant with BAT performance. Table 11-8 presents the O&M cost equation for the Metals option 4, secondary sulfide precipitation.

Table 11-8. Cost Equations for *Secondary (Sulfide) Precipitation* for Metals Option 4

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for secondary precip. and no treatment in-place	$\ln(Y1) = 13.829 + 0.544\ln(X) + 0.00000496(\ln(X))^2$	1.0 E -6 to 5.0
O&M cost for secondary precip. and no treatment in-place	$\ln(Y2) = 12.076 + 0.63456\ln(X) + 0.03678(\ln(X))^2$	1.8 E -4 to 5.0
Land requirements	$\ln(Y3) = -1.15 + 0.449\ln(X) + 0.027(\ln(X))^2$	2.5 E -4 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Plate and Frame Liquid Filtration and Clarification 11.2.2

Clarification systems provide continuous, low-cost separation and removal of suspended solids from water. Waste treatment facilities use clarification to remove particulates, flocculated impurities, and precipitants, often following chemical precipitation. Similarly, waste treatment facilities also use plate and frame pressure systems to remove solids from waste streams. As described in this section, these plate and frame filtration systems serve the same function as clarification and are used to remove solids following chemical precipitation from *liquid* wastestreams. The major difference between clarification systems and plate and frame liquid filtration systems is that the sludge generated by clarification generally needs to be processed further prior to landfilling, whereas, the sludge generated by plate and frame liquid filtration does not.

EPA costed facilities to include a plate and frame liquid filtration system following selective metals precipitation in Metals options 2 and 3. The components of the plate and frame liquid filtration system include: filter plates, filter cloth, hydraulic pumps, control panel, connector pipes, and a support platform. Since EPA costed all metals facilities for selective metals precipitation systems for metals options 2 and 3 (except the one facility which already utilizes this technology), EPA also costed all metals facilities for plate and frame liquid filtration systems. Consequently, EPA did not develop any upgrade costs associated with the use of plate and frame liquid filtration.

EPA also costed facilities to include a clarifier following secondary precipitation for Metals option 2 and following both secondary and tertiary precipitation for Metals option 3. For Metals option 4, EPA costed facilities to include a clarifier following primary chemical precipitation and following secondary precipitation (for direct dischargers only). EPA designed and costed a single clarification system for all options and locations in the treatment train. The components of this clarification system include a clarification unit, flocculation unit, pumps, motor, foundation, and accessories.

Plate and Frame Liquid Filtration Following Selective Metals Precipitation *11.2.2.1*

CAPITAL COSTS

The plate and frame liquid filtration equipment following the selective metals precipitation step for the model technology in Metals option 2 and 3 consists of two plate and frame liquid filtration systems. EPA assumed that each system would be used to process two batches per day for a total of four batches. EPA costed the plate and frame liquid filtration systems in this manner to allow facilities to segregate their wastes into smaller batches, thereby facilitating selective metals recovery. EPA sized each of the units to process a batch consisting of 25 percent of the daily flow and assumed that the influent to the plate and frame filtration units would consist of 96 percent liquid and four percent (40,000 mg/l) solids (based on the model facility). EPA based the capital cost equation for plate and frame liquid filtration for Metals options 2 and 3 on information provided by vendors. Table 11-9 lists this capital cost equation.

CHEMICAL USAGE AND LABOR REQUIREMENTS

EPA estimated that labor requirements for plate and frame liquid filtration for Metals options 2 and 3 would be 30 minutes per batch per filter press (based on the metals options 2 and 3 model facility). There are no chemicals associated with the operation of the plate and frame filtration systems. EPA estimated the remaining components of O&M using the factors listed in Table 11-2. Table 11-9 lists the O&M equation for plate and frame liquid filtration.

Even though the metal-rich sludge generated from selective metals precipitation and plate and frame liquid filtration may be recycled and re-used, EPA additionally included costs associated with disposal of these sludges in a landfill. The discussion for filter cake disposal is presented separately in Section 11.4.2. These disposal costs are additional O&M costs which must be added to the O&M costs calculated above to obtain the total O&M costs associated with plate and frame liquid filtration for Metals options 2 and 3.

Clarification for Metals Options 2,3, and 4 *11.2.2.2*

CAPITAL COSTS

EPA obtained the capital cost estimate for clarification systems from vendors. EPA designed the clarification system assuming an influent total suspended solids (TSS) concentration of 40,000 mg/L (four percent solids) and an effluent TSS concentration of 200,000 mg/L (20 percent solids). In addition, EPA assumed a design overflow rate of 600 gpd/ft^2. EPA estimated the influent and effluent TSS concentrations and overflow rate based on the WTI Questionnaire response for Questionnaire ID 105. The capital cost equation for clarification is presented in Table 11-9 at the end of this section. As detailed earlier, the same capital cost equation is used for all of the clarification systems for all of the metals options regardless of its location in the treatment train. EPA did not develop capital cost upgrades for facilities which already have clarification systems in-place. Therefore, facilities which currently have clarifiers have no land or capital costs.

CHEMICAL USAGE AND LABOR REQUIREMENTS

EPA estimated the labor requirements for the clarification systems for Metals options 2 and 3 following secondary precipitation and Metals option 4 following primary and secondary (for direct dischargers only) precipitation at three hours per day for low-flow clarifiers and four to six hours per day for high-flow clarifiers. Based on manufacturers recommendations, EPA selected the flow cut-off between high-flow and low-flow systems to be 1000 gallons per day. For the clarifier following tertiary precipitation in Metals option 3 only, EPA estimated the labor requirement at one hour per day (based on the operation of the Metals option 3 model facility). For all clarifiers for all metals options and treatment train locations, EPA estimated a polymer dosage rate of 2.0 mg per liter of wastewater (for the flocculation step) based on the MP&M industry cost model. EPA estimated the remaining components of O&M using the factors listed in Table 11-2. Table 11-9 lists the two cost equations developed for clarification. One equation is used for the clarifier following the tertiary precipitation step of Metals option 3 and the other equation is used for all other Metals options and locations in the treatment train.

As shown in Table 11-3, sludge filtration follows clarification for the secondary precipitation step of Metals options 2 and 3 and the primary and secondary (direct dischargers only) of Metals option 4. Section 11.4.1 and 11.4.2 present the costing discussion and equations for sludge filtration and the associated filter cake disposal.

For facilities which already have clarification systems or plate and frame liquid filtration systems in-place for each option and location in the treatment train, EPA estimated clarification upgrade costs. EPA assumed that in-place clarification systems and in-place plate and frame liquid filtration systems are equivalent. Therefore, if a facility has an in-place liquid filtration system which can serve the same purpose as a clarifier, EPA costed this facility for an up-grade only and not a new clarification system.

For the clarification step following secondary precipitation in Metals options 2 and 3, in order to quantify the O&M increase necessary for the O&M upgrade, EPA compared the difference between secondary precipitation current performance concentrations and the Metals option 2 long- term averages. EPA determined facilities would need to increase their current removals by 3 percent. Therefore, for in-place clarification systems (or plate and frame liquid filtration systems) which could serve as the clarifier following secondary chemical precipitation for Metals option 2 and 3, EPA included an O&M cost upgrade of three percent of the O&M costs for a brand new system (except for taxes, insurance, and maintenance which are a function of the capital cost). Table 11-9 lists the O&M upgrade equations for clarification following secondary chemical precipitation for Metals option 2 and 3 (one for facilities which currently have a clarifier and one for facilities which currently have a plate and frame liquid filtration system).

For facilities which already have clarifiers or plate and frame liquid filtration systems in-place which could serve as the clarifier following the tertiary chemical precipitation of Metals option 3, EPA did not estimate any O&M upgrade costs. EPA assumed the in-place technologies could perform as well as (or better) than the technology costed by EPA.

For facilities which already have clarifiers or plate and frame liquid filtration systems in-place which could serve as the clarifier following the primary chemical precipitation of Metals option 4, EPA compared the difference between primary precipitation current loadings and the long-term averages for Metals option 4, Sample Point - 03 (Sample Point - 03 follows primary precipitation and clarification at the Metals option 4 model facility). EPA determined that facilities would need to increase their removals by 2%. Therefore, for in-place clarification systems (or plate and frame liquid filtration systems) which could serve as the clarifier following primary chemical precipitation for Metals option 4, EPA included an O&M cost upgrade of two percent of the O&M costs for a brand new system (except for taxes, insurance, and maintenance which are a function of the capital cost). Table 11-9 lists the O&M upgrade equations for clarification following primary chemical precipitation for Metals option 4 (one for facilities which currently have a clarifier and one for facilities which currently have a plate and frame liquid filtration system).

EPA did not calculate an O&M upgrade equation for the clarification step following secondary chemical precipitation (direct dischargers only) of Metals option 4. EPA costed all direct discharging facilities for a new clarification system following secondary chemical precipitation for Metals option 4 since none of the direct discharging metals facilities had treatment in-place for this step.

Table 11-9. Cost Equations for *Clarification* and *Plate and Frame Liquid Filtration* in Metals Option 2,3,4

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for plate and frame liquid filtration - Metals Options 2 and 3[1]	$\ln(Y1) = 14.024 + 0.859\ln(X) + 0.040(\ln(X))^2$	1.0 E -6 to 1.0
Capital Cost for Clarification - Metals Options 2,3, and 4	$\ln(Y1) = 11.552 + 0.409\ln(X) + 0.020(\ln(X))^2$	4.0 E -5 to 1.0
O&M cost for plate and frame liquid filtration - Metals Options 2 and 3[1]	$\ln(Y2) = 13.056 + 0.193\ln(X) + 0.00343(\ln(X))^2$	1.0 E -6 to 1.0
O&M cost for Clarification - Metals Options 2,3[3], and 4	$\ln(Y2) = 10.673 + 0.238\ln(X) + 0.013(\ln(X))^2$	1.2 E -4 to 1.0
O&M cost for clarification - Metals Option 3[4]	$\ln(Y2) = 10.294 + 0.362\ln(X) + 0.019(\ln(X))^2$	8.0 E -5 to 1.0
O&M *upgrade* for Clarification - Metals Options 2 and 3 facilities which currently have clarification in-place[5]	$\ln(Y2) = 7.166 + 0.238\ln(X) + 0.013(\ln(X))^2$	7.0 E -5 to 1.0
O&M *upgrade* for Clarification - Metals Options 2 and 3 facilities which currently have plate&frame liquid filtration in-place	$\ln(Y2) = 8.707 + 0.333\ln(X) + 0.012(\ln(X))^2$	1.0 E -6 to 1.0
O&M *upgrade* for Clarification - Metals Option 4[6]	$\ln(Y2) = 6.8135 + 0.3315\ln(X) + 0.0242(\ln(X))^2$	1.2 E -3 to 1.0
O&M *upgrade* for plate and frame liquid filtration - Metals Option 4	$\ln(Y2) = 12.0242 + 1.17676\ln(X) + 0.05005(\ln(X))^2$	1.0 E-6 to 1.0
Land requirements for plate and frame liquid filtration - Metals Options 2 and 3	$\ln(Y3) = -1.658 + 0.185\ln(X) + 0.009(\ln(X))^2$	1.0 E -6 to 1.0
Land requirements for clarification	$\ln(Y3) = -1.773 + 0.513\ln(X) + 0.046(\ln(X))^2$	1.0 E -2 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

[1]Follows selective metals precipitation
[3]For metals option 3, this equation is used for clarification following secondary chemical precipitation only
[4]This equation is used for clarification following tertiary precipitation only.
[5]For Metals Option 3, this equation is used for clarification following secondary precipitation only. No O&M upgrade costs included for tertiary precipitation.
[6]This equation is used for clarification following primary precipitation only. No facilities require O&M upgrades for clarification following secondary chemical precipitation.

Equalization *11.2.3*

To improve treatment, facilities often need to equalize wastes by holding them in a tank. The CWT industry frequently uses equalization to minimize the variability of incoming wastes effectively.

EPA costed an equalization system which consists of a mechanical aeration basin based on responses to the WTI Questionnaire. EPA obtained the equalization cost estimates from the 1983 U.S. Army Corps of Engineers' Computer Assisted Procedure for Design and Evaluation of Wastewater Treatment Systems (CAPDET). EPA originally used this program to estimate equalization costs for the OCPSF Industry. Table11-10 lists the default design parameters that EPA used in the CAPDET program. These default design parameters are reasonable for the CWT industry since they reflect values seen in the CWT industry. For example, the default detention time (24 hours) is appropriate since this was the median equalization detention time reported by respondents to the WTI Questionnaire.

Table 11-10. Design Parameters Used for Equalization in CAPDET Program

Aerator mixing = 0.03 HP per 1,000 gallons;
Oxygen requirements = 15.0 mg/l per hour;
Dissolved oxygen in basin = 2.0 mg/l;
Depth of basin = 6.0 feet; and
Detention time = 24 hours.

EPA did not calculate capital or O&M upgrade equations for equalization. If a CWT facility currently has an equalization tank in-place, the facility received no costs associated with equalization. EPA assumed that the equalization tanks currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

CAPITAL COSTS

The CAPDET program calculates capital costs which are "total project costs." These "total project costs" include all of the items previously listed in Table 11-1 as well as miscellaneous nonconstruction costs, 201 planning costs, technical costs, land costs, interest during construction, and laboratory costs. Therefore, to obtain capital costs for the equalization systems for this industry, EPA calculated capital costs based on total project costs minus: miscellaneous nonconstruction costs, 201 planning costs, technical costs, land costs, interest during construction, and laboratory costs. Table 11-11 at the end of this section presents the resulting capital cost equation for equalization.

OPERATION AND MAINTENANCE COSTS

EPA obtained O&M costs directly from the initial year O&M costs produced by the CAPDET program. Table 11-11 presents the O&M cost equation for equalization systems.

LAND REQUIREMENTS

EPA used the CAPDET program to develop land requirements for the equalization systems. EPA scaled up the requirements to represent the total land required for the system plus peripherals (pumps, controls, access areas, etc.). The land requirement equation for equalization systems is also presented in Table 11-11.

Table 11-11. Summary of Cost Equations for *Equalization*

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for equalization	$\ln(Y1) = 12.057 + 0.433\ln(X) + 0.043(\ln(X))^2$	6.6 E -3 to 5.0
O&M cost for equalization	$\ln(Y2) = 11.723 + 0.311\ln(X) + 0.019(\ln(X))^2$	3.0 E -4 to 5.0
Land requirements	$\ln(Y3) = -0.912 + 1.120\ln(X) + 0.011(\ln(X))^2$	1.4 E -2 to 5.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Air Stripping *11.2.4*

Air stripping is an effective wastewater treatment method for removing dissolved gases and volatile compounds from wastewater streams. The technology passes high volumes of air through an agitated gas-water mixture. This promotes volatilzation of compounds, and, preferably capture in air pollution control systems.

The air stripping system costed by EPA includes transfer pumps, control panels, blowers, and ancillary equipment. EPA also included catalytic oxidizers as part of the system for air pollution control purposes.

If a CWT facility currently has an air stripping system in-place, EPA did not assign the facility any costs associated with air stripping. EPA assumed that the air stripping systems currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

CAPITAL COSTS

EPA's air stripping system is designed to remove pollutants with medium to high volatilities. EPA used the pollutant 1,2-dichloroethane, which has a Henry's Law Constant of 9.14 E -4 atm*L/mol, as the design basis with an influent concentration of 4,000 µg/L and an effluent concentration of 68 µg/L. EPA based these concentration on information collected on the model facility's operation. EPA used the same design basis for the air stripping systems costed for the option 8v and 9v in the oils subcategory.

EPA obtained the equipment costs from vendor quotations. Table 11-13 at the end of this section presents the capital cost equation for air stripping systems.

OPERATION AND MAINTENANCE COSTS

For air stripping, O&M costs include electricity, maintenance, labor, catalyst replacement, and taxes and insurance. EPA obtained the O&M costs from the same vendor which provided the capital cost estimates.

EPA based the electricity usage for the air strippers on the amount of horsepower needed to operate the system and approximated the electricity usage for the catalytic oxidizers at 50 percent of the electricity used for the air strippers. EPA based both the horsepower requirements and the electricity requirements for the catalytic oxidizer on vendor's recommendations. EPA estimated the labor requirement for the air stripping system at three hours per day, which is based on the model facility's operation. EPA assumed that the catalyst beds in the catalytic oxidizer would require replacement every four years based on the rule of thumb (provided by the vendor) that precious metal catalysts have a lifetime of approximately four years. EPA divided the costs for replacing the spent catalysts by four to convert them to annual costs. As is the standard used by EPA for this industry, taxes and insurance were estimated at 2 percent of the total capital cost. Table 11-12 presents the resulting O&M cost equation for air stripping systems.

Table 11-12. Cost Equations for *Air Stripping*

Description	Equation	Recommended Flow Rate Range(MGD)
Capital cost for air stripping	$\ln(Y1) = 12.899 + 0.486\ln(X) + 0.031(\ln(X))^2$	4.0 E -4 to 1.0
O&M cost for air stripping	$\ln(Y2) = 10.865 + 0.298\ln(X) + 0.021(\ln(X))^2$	8.5 E -4 to 1.0
Land requirements	$\ln(Y3) = -2.207 + 0.536\ln(X) + 0.042(\ln(X))^2$	0.1 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Multi-Media Filtration *11.2.5*

Filtration is a proven technology for the removal of residual suspended solids from wastewater. The multimedia filtration system costed by EPA for this industry is a system which contains sand and anthracite coal, supported by gravel.

EPA based the design for the model multimedia filtration system on the TSS effluent long- term average concentration for Metals option 4 -- 15 mg/L. EPA assumed that the average influent TSS concentration to the multimedia filtration system would range from 75 to 100 mg/L. EPA based the influent concentration range on vendor's recommendations on realistic TSS concentrations resulting from wastewater treatment following chemical precipitation and clarification.

EPA did not calculate capital or O&M upgrade equations for multi-media filtration. If a CWT facility currently has a multimedia filter in-place, EPA assigned the facility no costs associated with multi-media filtration. EPA assumed that the multi-media filter currently in-place at CWT facilities would perform as well as (or better than) the system costed by EPA.

CAPITAL COSTS

EPA based the capital costs of multi-media filters on vendor's recommendations. Table 11-13 presents the resulting capital cost equation for multi-media filtration systems.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

EPA estimated the labor requirement for the multi-media filtration system at four hours per day, which is based on manufacturer's recommendations. There are no chemicals associated with the operation of a multimedia filter. Table 11-13 presents the O&M cost equation for the multi-media filtration system.

Table 11-13. Cost Equations for *Multi-Media Filtration*

Description	Equation	Flow Rate Range (MGD)
Capital cost for multi-media filtration	$\ln(Y1) = 12.0126 + 0.48025\ln(X) + 0.04623(\ln(X))^2$	5.7 E -3 to 1.0
O&M cost for multi-media filtration	$\ln(Y2) = 11.5039 + 0.72458\ln(X) + 0.09535(\ln(X))^2$	2.3 E -2 to 1.0
Land requirements	$\ln(Y3) = -2.6569 + 0.19371\ln(X) + 0.02496(\ln(X))^2$	2.4 E -2 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Cyanide Destruction *11.2.6*

Many CWTs achieved required cyanide destruction by oxidation. These facilities primarily use chlorine (in either the elemental or hypochlorite form) as the oxidizing agent in this process. Oxidation of cyanide with chlorine is called alkaline chlorination.

The oxidation of cyanide waste using sodium hypochlorite is a two step process. In the first step, cyanide is oxidized to cyanate in the presence of hypochlorite, and sodium hydroxide is used to maintain a pH range of 9 to 11. The second step oxidizes cyanate to carbon dioxide and nitrogen at a controlled pH of 8.5. The amounts of sodium hypochlorite and sodium hydroxide needed to perform the oxidation are 8.5 parts and 8.0 parts per part of cyanide, respectively. At these levels, the total reduction occurs at a retention time of 16 to 20 hours. The application of heat can facilitate the more complete destruction of total cyanide.

The cyanide destruction system costed by EPA includes a two-stage reactor with a retention time of 16 hours, feed system and controls, pumps, piping, and foundation. The two-stage reactor includes a covered tank, mixer, and containment tank. EPA designed the system based on a total cyanide influent concentration of 4,633,710 µg/L and an effluent concentration of total cyanide of 135,661 µg/L. EPA based these influent and effluent concentrations on data collected during EPA's sampling of cyanide destruction systems.

Because the system used by the facility which forms the basis of the cyanide limitations and standards uses special operation conditions, EPA assigned full capital and O&M costs to all facilities which perform cyanide destruction.

CAPITAL COSTS

EPA obtained the capital costs curves for cyanide destruction systems with special operating conditions from vendor services. Table 11-14 presents the capital cost equation.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

In estimating chemical usage and labor requirements, EPA assumed the systems would treat one batch per day. EPA based this assumption on responses to the WTI Questionnaire. Based on vendor's recommendations, EPA estimated the labor requirement for the cyanide destruction to be three hours per day. EPA determined the amount of sodium hypochlorite and sodium hydroxide required based on the stochiometric amounts to maintain the proper pH and chlorine concentrations to facilitate the cyanide destruction as described earlier. Table 11-14 presents the O&M cost equation for cyanide destruction.

Table 11-14. Cost Equations for *Cyanide Destruction*

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for cyanide destruction	$\ln(Y1) = 13.977 + 0.546\ln(X) + 0.0033(\ln(X))^2$	1.0 E -6 to 1.0
O&M cost for cyanide destruction	$\ln(Y2) = 18.237 + 1.318\ln(X) + 0.04993(\ln(X))^2$	1.0 E -5 to 1.0
Land requirements	$\ln(Y3) = -1.168 + 0.419\ln(X) + 0.021(\ln(X))^2$	1.0 E -4 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Secondary Gravity Separation *11.2.7*

Primary gravity separation provides oil and grease removal from oily wastewater. During gravity separation, the wastewater is held in tanks under quiescent conditions long enough to allow the oil droplets to rise and form a layer on the surface, where it is skimmed.

Secondary gravity separation systems provide additional oil and grease removal for oily wastewater. Oily wastewater, after primary gravity separation/emulsion breaking, is pumped into a series of skimming tanks where additional oil and grease removal is obtained before the wastewater enters the dissolved air flotation unit. The secondary gravity separation equipment discussed here consists of a series of three skimming tanks in series. The ancillary equipment for each tank consists of a mix tank with pumps and skimming equipment.

In estimating capital and O&M cost associated with secondary gravity separation, EPA assumed that facilities either currently have or do not have secondary gravity separation. Therefore, EPA did not develop any secondary gravity separation upgrade costs.

CAPITAL COSTS

EPA obtained the capital cost estimates for the secondary gravity separation system from vendor quotes. Table 11-15 at the end of this section presents the capital cost equation for secondary gravity separation.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

EPA estimated the labor requirement to operate secondary gravity separation to be 3 to 9 hours per day depending on the size of the system. EPA obtained this estimate from one of the model facilities for Oils option 9. There are no chemicals associated with the operation of the secondary gravity separation system. Table 11-15 presents the O&M Cost equation for the secondary gravity separation system.

Table 11-15. Cost Equations for *Secondary Gravity Separation*

Description	Equation	Recommended Flow Rate Range (MGD)
Capital cost for secondary gravity separation	$\ln(Y1) = 14.3209 + 0.38774\ln(X) - 0.01793(\ln(X))^2$	5.0 E -4 to 5.0
O&M cost for secondary gravity separation	$\ln(Y2) = 12.0759 + 0.4401\ln(X) + 0.01544(\ln(X))^2$	5.0 E -4 to 5.0
Land requirements	$\ln(Y3) = -0.2869 + 0.31387\ln(X) + 0.01191(\ln(X))^2$	1.0 E -6 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

Dissolved Air Flotation *11.2.8*

Flotation is the process of inducing suspended particles to rise to the surface of a tank where they can be collected and removed. Dissolved Air Flotation (DAF) is one of several flotation techniques employed in the treatment of oily wastewater. DAF is commonly used to extract free and dispersed oil and grease from oily wastewater.

CAPITAL COSTS

EPA developed capital cost estimates for dissolved air flotation systems for the oils subcategory options 8 and 9. EPA based the capital cost estimates for the DAF units on quotations from vendors. EPA assigned facilities with DAF units currently in-place no capital costs. For facilities with no DAF treatment in-place, the DAF system consists of a feed unit, a chemical addition mix tank, and a flotation tank. EPA also included a sludge filtration/dewatering unit. EPA developed capital cost estimates for a series of flow rates ranging from 25 gpm (0.036 MGD) to 1000 gpm (1.44 MGD). EPA was unable to obtain costs estimates for units with flows below 25 gallons per minute since manufacturers do not sell systems smaller than those designed for flows below 25 gallons per minute.

The current DAF system capital cost estimates include a sludge filtration/dewatering unit. For facilities which do not have a DAF unit in-place, but have other treatment systems that produce sludge (i.e. chemical precipitation and/or biological treatment), EPA assumed that the existing sludge filtration unit could accommodate the additional sludge produced by the DAF unit. For these facilities, EPA did not include sludge filtration/dewatering costs in the capital cost estimates. EPA refers to the capital cost equation for these facilities as "modified" DAF costs. Table 11-17 at the end of this section presents the resulting total capital cost equations for the DAF and "modified" DAF treatment systems.

Because the smallest design capacity for DAF systems that EPA could obtain from vendors is 25 gpm and since more than 75 percent of the oils subcategory facilities have flow rates lower than 25 gpm, EPA assumed that only facilities with flow rates above 20 gpm would operate their DAF systems everyday (i.e. five days per week). EPA assumed that the rest of the facilities could hold their wastewater and run their DAF systems from one to four days per week depending on their flowrate. Facilities that are not operating their DAF treatment systems everyday would need to install a holding tank to hold their wastewater until treatment. Therefore, for facilities that do not currently have DAF treatment in place and have flow rates less than 20 gallons per minute, EPA additionally included costs for a holding tank. For these facilities, EPA based capital costs on a combination of DAF costs (or modified DAF costs) and holding tank costs. Table 11-16A lists the capacity of the holding tank costed for various flowrates.

Table 11-16A. Estimate Holding Tank Capacities for DAF Systems

Flowrate (GPM)	Holding Tank Capacity (gallons)
<5	7,200
5-10	14,400
10-15	21,600
15-20	28,800
>20	none

Table 11-17 at the end of this section presents the resulting capital cost equation for the holding tank associated with the DAF and modified DAF systems.

CHEMICAL USAGE AND LABOR REQUIREMENT COSTS

EPA estimated the labor requirements associated with the model technology at four hours per day for the small systems to eight hours per day for the large systems, which is based on the average of the Oils options 8 and 9 model facilities. EPA used the same labor estimate for DAF and "modified" DAF systems.

As discussed in the capital cost section, EPA has assumed that facilities with flow rates below 20 gpm will not operate the DAF daily. Therefore, for these lower flow rate facilities, EPA only included labor to operate the DAF (or "modified" DAF) systems for the days the system will be operational. Table 11-16B lists the number of days per week EPA assumed these lower flow facilities would operate their DAF systems.

Table 11-16B. Estimate Labor Requirements for DAF Systems

Flowrate (GPM)	Labor Requirements (days/week)
<5	1
5-10	2
10-15	3
15-20	4
>20	5

As detailed earlier, however, EPA also assumed that facilities with flow rates below 20 gpm, would also operate a holding tank. Therefore, for facilities with flow rates below 20 gallons per minute, EPA included additional labor to operate the holding tank.

EPA calculated chemical cost estimates for DAF and "modified" DAF systems based on additions of aluminum sulfate, caustic soda, and polymer. EPA costed for facilities to add 550 mg/L alum, 335 mg/L polymer and 1680 mg/L of NaOH. EPA also included costs for perlite addition at 0.25 lbs per lb of dry solids for sludge conditioning and sludge dewatering operations (for DAF, but not "modified" DAF systems). EPA based the chemical additions on information gathered from literature, the database for the Industrial Laundries Industry guidelines and standards, and sampled facilities.

Finally, similar to the labor requirements shown in table 11-16B, EPA based chemical usage cost estimates for the DAF and modified DAF systems assuming five days per week operation for facilities with flowrates greater than 20 gpm and from one to four days per week for facilities with flowrates of 5 to 20 gpm.

Table 11-17 at the end of this section presents the four equations relating the various types of O&M costs developed for DAF treatment for facilities with no DAF treatment.

For facilities with DAF treatment in-place, EPA estimated O&M upgrade costs. These facilities would need to improve pollutant removals from their current DAF current performance concentrations to the Oils option 8 and option 9 long-term averages. As detailed in Chapter 12, EPA does not have current performance concentration data for the majority of the oils facilities with DAF treatment in-place. EPA does, however, have seven long-term sampling data sets which represent effluent concentrations from emulsion breaking/gravity separation. While the pollutant concentrations in wastewater exiting emulsion breaking/gravity separation treatment are higher (in some cases, considerably higher) than the pollutant concentrations in wastewater exiting DAF treatment, EPA has, nevertheless, used the emulsion breaking/gravity separation long-term sampling data sets to estimate DAF upgrade costs. For each of the seven emulsion breaking/gravity separation data sets, EPA calculated the percent difference between these concentrations and the option 8 and option 9 long-term averages. The median of these seven calculated percentages is 25 percent.

Therefore, EPA estimated the energy, labor, and chemical cost components of the O&M upgrade cost as 25 percent of the full O&M cost of a new system. EPA assumed that maintenance, and taxes and insurance would be zero since they are functions of the capital cost (that is, there is no capital cost for the upgrade). EPA developed two separate O&M upgrade cost equations for facilities which currently have DAF treatment in place -- one for facilities with flowrates up to 20 gpm and one for facilities with flow rates greater than 20 gpm. Table 11-17 presents the two equations representing O&M upgrade costs for facilities with DAF treatment in-place.

Table 11-17. Cost Equations for *Dissolved Air Flotation (DAF)* in Oils Options 8 and 9

Description	Equation	Recommended Flow Rate Range (MGD)
Total capital cost for DAF	$\ln(Y1) = 13.9518 + 0.29445\ln(X) - 0.12049(\ln(X))^2$	0.036 to 1.44
Total capital cost for modified DAF	$\ln(Y1) = 13.509 + 0.29445\ln(X) - 0.12049(\ln(X))^2$	0.036 to 1.44
Holding tank capital cost for DAF and modified DAF[1]	$\ln(Y1) = 12.5122 - 0.15500\ln(X) - 0.5618(\ln(X))^2$	5.0 E -4 to 0.05
O&M cost for DAF with flowrate above 20 gpm	$\ln(Y2) = 14.5532 + 0.96495\ln(X) + 0.01219(\ln(X))^2$	0.036 to 1.44
O&M cost for modified DAF with flowrate above 20 gpm	$\ln(Y2) = 14.5396 + 0.97629\ln(X) + 0.01451(\ln(X))^2$	0.036 to 1.44
O&M cost for DAF with flowrate up to 20 gpm	$\ln(Y2) = 21.2446 + 4.14823\ln(X) + 0.36585(\ln(X))^2$	7.2 E -3 to 0.029
O&M cost for modified DAF with flowrate up to 20 gpm	$\ln(Y2) = 21.2005 + 4.07449\ln(X) + 0.34557(\ln(X))^2$	7.2 E -3 to 0.029
O&M *upgrade* for DAF with flowrate below 20 gpm	$\ln(Y2) = 19.0459 + 3.5588\ln(X) + 0.25553(\ln(X))^2$	7.2 E -3 to 0.029
O&M *upgrade* for DAF with flowrate above 20 gpm	$\ln(Y2) = 13.1281 + 0.99778\ln(X) + 0.01892(\ln(X))^2$	0.036 to 1.44
Land required for holding tank[1]	$\ln(Y3) = -1.0661 + 0.10066\ln(X) + 0.00214(\ln(X))^2$	5.0 E -4 to 0.05
Land required for DAF and modified DAF	$\ln(Y3) = -0.5107 + 0.51217\ln(X) - 0.01892(\ln(X))^2$	0.036 to 1.44

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)
[1]Only facilities with flow rates below 20 gpm receive holding tank costs.

BIOLOGICAL WASTEWATER TREATMENT TECHNOLOGY COSTS 11.3

Sequencing Batch Reactors 11.3.1

A sequencing batch reactor (SBR) is a suspended growth system in which wastewater is mixed with retained biological floc in an aeration basin. SBR's are unique in that a single tank acts as an equalization tank, an aeration tank, and a clarifier.

The SBR system costed by EPA for the model technology consists of a SBR tank, sludge handling equipment, feed system and controls, pumps, piping, blowers, and valves. The design parameters that EPA used for the SBR system were the average influent and effluent BOD_5, ammonia, and nitrate-nitrite concentrations. The average influent concentrations were 4800 mg/L, 995 mg/L, and 46 mg/L for BOD_5, ammonia, and nitrate-nitrite, respectively. The average effluent BOD_5, ammonia, and nitrate-nitrite concentrations used were 1,600 mg/l, 615 mg/l, and 1.0 mg/l, respectively. EPA obtained these concentrations from the sampling data at the SBR model facility. EPA assumed that all existing biological treatment systems in-place at organics subcategory facilities can meet the limitations of this rule without incurring cost. This includes facilities which utilize any form of biological treatment -- not just SBRs. Therefore, the costs presented here only apply to facilities without biological treatment in-place. EPA did not develop SBR upgrade costs for either capital or O&M.

Although biological treatment (SBR's) systems can be used throughout the United States, the design of the systems should vary due to climate conditions. Plants in colder climates should design their systems to account for lower biodegradability rates during the colder seasons. Therefore, EPA has taken these added costs into account in its costing procedures (see Section 3.1 of the Detailed Costing Document).

CAPITAL COSTS

EPA estimated the capital costs for the SBR systems using vendor quotes which include installation costs. Table 11-18 at the end of this section presents the SBR capital cost equation.

OPERATION AND MAINTENANCE COSTS

The O&M costs for the SBR system include electricity, maintenance, labor, and taxes and insurance. No chemicals are utilized in the SBR system. EPA assumed the labor requirements for the SBR system to be four hours per day and based electricity costs on horsepower requirements. EPA obtained the labor and horsepower requirements from vendors. EPA estimated maintenance, taxes, and insurance using the factors detailed in Table 11-2. Table 11-18 presents the SBR O&M cost equation.

Table 11-18. Cost Equations for *Sequencing Batch Reactors*

Description	Equation	Recommended Flow Rate Range(MGD)
Capital cost for sequencing batch reactors	$\ln(Y1) = 15.707 + 0.512\ln(X) + 0.0022(\ln(X))^2$	1.0 E -7 to 1.0
O&M cost for sequencing batch reactors	$\ln(Y2) = 14.1015 + 0.81567\ln(X) + 0.03932(\ln(X))^2$	3.4 E -7 to 1.0
Land requirements	$\ln(Y3) = -0.531 + 0.906\ln(X) + 0.072(\ln(X))^2$	1.9 E -3 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

SLUDGE TREATMENT AND DISPOSAL COSTS *11.4*

Plate and Frame Pressure Filtration -- Sludge Stream *11.4.1*

Pressure filtration systems are used for the removal of solids from waste streams. This section details *sludge stream* filtration which is used to treat the solids removed by the clarifiers in the metals options.

The pressure filtration system costed by EPA for sludge stream filtration consists of a plate and frame filtration system. The components of the plate and frame filtration system include: filter plates, filter cloth, hydraulic pumps, pneumatic booster pumps, control panel, connector pipes, and a support platform. For design purposes, EPA assumed the sludge stream to consist of 80 percent liquid and 20 percent (200,000 mg/l) solids. EPA additionally assumed the sludge stream to be 20 percent of the total volume of wastewater treated. EPA based these design parameters on CWT Questionnaire 105.

In costing for sludge stream treatment, if a facility does not have sludge filtration systems in-place, EPA estimated capital costs to add a plate and frame pressure filtration system to their on-site treatment train[2]. If a facility's treatment train includes more than one clarification step in its treatment train (such as for Metals option 3), EPA only costed the facility for a single plate and frame filtration system. EPA assumed one plate and frame filtration system could be used to process the sludge from multiple clarifiers. Likewise, if a facility already had a sludge filtration system in-place, EPA assumed that the in-place system would be sufficient and did not estimate any sludge filtration capital costs for these facilities.

CAPITAL COSTS

EPA developed the capital cost equation for plate and frame sludge filtration by adding installation, engineering, and contingency costs to vendors' equipment cost estimates. EPA used the same capital cost equation for the plate and frame sludge filtration system for all of the metals options. Table 11-19 presents the plate and frame sludge filtration system capital cost equation.

OPERATION AND MAINTENANCE COSTS
METALS OPTION 2 AND 3

The operation and maintenance costs for metals option 2 and 3 plate and frame sludge filtration consist of labor, electricity, maintenance, and taxes and insurance. EPA approximated the labor requirements for the plate and frame sludge filtration system to be thirty minutes per batch based on the Metals option 2 and 3 model facility. Because no chemicals are used with the plate and frame sludge filtration units, EPA did not include costs for chemicals. EPA estimated electricity, maintenance, and taxes and insurance using the factors listed in Table 11-2. Table 11-19 lists the resulting plate and frame sludge filtration O&M cost equation.

For facilities which already have a sludge filtration system in-place, EPA included plate and frame filtration O&M upgrade costs. Since the sludge generated from the secondary precipitation and clarification steps in metals option 2 and 3 is the sludge which requires treatment for these options, these facilities would be required to improve pollutant removals from their secondary precipitation current performance concentrations to the long term averages for Metals options 2. Therefore, EPA calculated the

[2] If a facility only had to be costed for a plate and frame pressure filtration system to process the sludge produced during the tertiary chemical precipitation and clarifications steps of metals Option 3, EPA did not cost the facility for a plate and frame pressure filtration system. Likewise, EPA assumed no O&M costs associated with the treatment of sludge from the tertiary chemical precipitation and clarification steps in Metals Option 3. EPA assumed that the total suspended solids concentration at this point is so low that sludge stream filtration is unnecessary.

percent difference between secondary precipitation current performance and the Metals option 2 long-term averages. EPA determined this percentage to be an increase of three percent.

As such, for facilities which currently have sludge filtration systems in place, for metals option 2 and 3, EPA included an O&M upgrade cost which is three percent of the O&M costs of a new system (except for taxes and insurance, which are a function of the capital cost). Table 11.19 presents the O&M upgrade cost equation for sludge filtration in Metals option 2 and option 3.

OPERATION AND MAINTENANCE COSTS *METALS OPTION 4*

The operation and maintenance costs for metals option 4 consists of labor, chemical usage, electricity, maintenance, taxes, and insurance, and filter cake disposal. The O&M plate and frame sludge filtration costing methodology for Metals option 4 is very similar to the one discussed previously for Metals option 2 and 3. The primary differences in the methodologies are the estimation of labor, the inclusion of filter cake disposal, and the O&M upgrade methodology.

EPA approximated the labor requirement for Metals option 4 plate and frame sludge filtration systems at 2 to 8 hours per day depending on the size of the system. As was the case for metals option 2 and 3, no chemicals are used in the plate and frame sludge filtration units for metals option 4, and EPA estimated electricity, maintenance and taxes and insurance using the factors listed in Table 11-2. EPA also included filter cake disposal costs at $0.74 per gallon of filter cake. A detailed discussion of the basis for the filter cake disposal costs is presented in Section 11.4.2. Table 11-19 presents the O&M cost equation for sludge filtration for Metals option 4.

Table 11-19. Cost Equations for *Plate and Frame Sludge Filtration* in Metals Options 2, 3 and 4

Description	Equation	Recommended Flow Rate Range (MGD)
Capital costs for plate and frame sludge filtration	$\ln(Y1) = 14.827 + 1.087\ln(X) + 0.0050(\ln(X))^2$	2.0 E -5 to 1.0
O&M costs for sludge filtration for Metals Option 2 and 3[1,3]	$\ln(Y2) = 12.239 + 0.388\ln(X) + 0.016(\ln(X))^2$	2.0 E -5 to 1.0
O&M costs for sludge filtration for Metals Option 4[4]	$\ln(Y2) = 15.9321 + 1.177\ln(X) + 0.04697(\ln(X))^2$	1.0 E -5 to 1.0
O&M *upgrade* costs for sludge filtration for Metals Option 2,3[1,3]	$\ln(Y2) = 8.499 + 0.331\ln(X) + 0.013(\ln(X))^2$	2.0 E -5 to 1.0
O&M *upgrade* cost for sludge filtration for Metals Option 4[4]	$\ln(Y2) = 12.014 + 1.17846\ln(X) + 0.050(\ln(X))^2$	1.0 E -5 to 1.0
Land requirements for sludge filtration	$\ln(Y3) = -1.971 + 0.281\ln(X) + 0.018(\ln(X))^2$	1.8 E -3 to 1.0

Y1 = Capital Costs (1989 $)
Y2 = Operation and Maintenance Costs (1989 $ /year)
Y3 = Land Requirement (Acres)
X = Flow Rate (million gallons per day)

[1]Following secondary chemical precipitation/clarification only. EPA assumed the sludge generated from tertiary precipitation/clarification would not be a significant quantity.

[3]This equation does not include filter cake disposal costs.

[4]This equation includes filter cake disposal costs.

For facilities which already have a sludge filtration system in-place, EPA included sludge stream filtration O&M upgrade costs. For Metals option 4, EPA included these O&M upgrade costs for processing the sludge generated from the primary precipitation and clarification steps[3]. These facilities would need to improve pollutant removals from their primary precipitation current performance concentrations to Metals option 4 (Sample Point - 03) concentrations. This sample point represents the effluent from the liquid-solids separation unit following primary chemical precipitation at the Metals option 4 model facility. Therefore, EPA calculated the percent difference between primary precipitation current performance concentrations and Metals option 4 (Sample Point - 03) concentrations. EPA determined that there was an increase of two percent.

As such, for facilities which currently have sludge filtration systems in place, for metals option 4, EPA included an O&M cost upgrade of two percent of the total O&M costs (except for taxes and insurance, which are a function of the capital cost). Table 11-19 presents the O&M upgrade cost equation for sludge filtration for Metals option.

Filter Cake Disposal 11.4.2

The liquid stream and sludge stream pressure filtration systems presented in Sections 11.2.3 and 11.4.1, respectively, generate a filter cake residual. There is an annual O&M cost that is associated with the disposal of this residual. This cost must be added to the pressure filtration equipment O&M costs to arrive at the total O&M costs for pressure filtration operation[4].

To determine the cost of transporting and disposing filter cake to an off-site facility, EPA performed an analysis on a subset of questionnaire respondents in the WTI Questionnaire response database. This subset consists of metals subcategory facilities that are direct and/or indirect dischargers and that provided information on contract haul and disposal cost to hazardous (Subtitle C) and non-hazardous (Subtitle D) landfills. From this set of responses, EPA tabulated two sets of costs -- those reported for Subtitle C contract haul and disposal and those reported for Subtitle D contract haul and disposal. the reported costs for both the Subtitle C and Subtitle D contract haul/disposal. EPA then edited this information by excluding data that was incomplete or that was not separated by RCRA classification.

EPA used the reported costs information in this data set to determine the median cost for both the Subtitle C and Subtitle D disposal options, and then calculated the weighted average of these median costs. The average was weighted to reflect the ratio of hazardous (67 percent) to nonhazardous (33 percent) waste receipts at these Metals Subcategory facilities. The final disposal cost is $0.74 per gallon of filter cake.

EPA calculated a single disposal cost for filter cake using both hazardous and non-hazardous landfilling costs. Certain facilities will incur costs, however, that, in reality, are higher and others will incur costs that, in reality, are lower. Thus, some low revenue metals subcategory facilities that generate non-hazardous sludge may show a higher economic burden than is representative. On the other hand, some low revenue metals subcategory facilities that generate hazardous sludge may

[3] EPA did not include O&M upgrade costs for the sludge generated from the secondary precipitation and clarification step (direct dischargers only).

[4] Note that these costs have already been included in the O&M equation for plate and frame sludge filtration for Metals Option 4.

show a lower economic burden than is representative. EPA has concluded that in the end, these over- and under estimates will balance out to provide a representative cost across the industry.

Table 11-20 presents the O&M cost equation for filter cake disposal for Metals option 2 and option 3. Table 11-20 additionally presents an O&M upgrade for filter cake disposal resulting from Metals option 2 and option 3 for facilities that already generate filter cake as part of their operation.

This upgrade is 3 percent of the cost of the O&M upgrade for facilities that do not already generate filter cake as a part of their operation. EPA used 3 percent because this was the same percentage calculated for plate and frame sludge filtration for these same options.

Table 11-20. Cost Equations for *Filter Cake Disposal* for Metals Options 2 and 3[1]

Description	Equation	Recommended Flow Rate Range (GPM)
O&M cost for filter cake disposal	Z = 0.109169 + 7,695,499.8(X)	1.0 E -6 to 1.0
O&M *upgrade* for filter cake disposal	Z = 0.101186 + 230,879.8(X)	1.0 E -6 to 1.0

Z = Filter Cake Disposal Cost (1989 $ / year)
X = Flow Rate (million gallons per day)
[1]Filter cake disposal costs for Metals Option 4 are included in the sludge filtration equations.

ADDITIONAL COSTS *11.5*

Retrofit Costs *11.5.1*

EPA assigned costs to the CWT Industry on both an option- and facility-specific basis. The option-specific approach estimated compliance cost for a sequence of individual treatment technologies, corresponding to a particular regulatory option, for a subset of facilities defined as belonging to that regulatory subcategory. Within the costing of a specific regulatory option, EPA assigned treatment technology costs on a facility-specific basis depending upon the technologies determined to be currently in-place at the facility.

Once EPA determined that a treatment technology cost should be assigned to a particular facility, EPA considered two scenarios. The first was the installation of a new individual treatment technology as a part of a new treatment train. The full capital costs presented in Subsections 11.2 through 11.4 of this document apply to this scenario. The second scenario was the installation of a new individual treatment technology which would have to be integrated into an existing in-place treatment train. For these facilities, EPA applied retrofit costs. These retrofit costs cover such items as piping and structural modifications which would be required in an existing piece of equipment to accommodate the installation of a new piece of equipment prior to or within an existing treatment train.

For all facilities which received retrofit costs, EPA added a retrofit factor of 20 percent of the total capital cost of the newly-installed or upgraded treatment technology unit that would need to be integrated into an existing treatment train. These costs are in addition to the specific treatment technology capital costs calculated with the technology specific equations described in earlier sections.

Monitoring Costs *11.5.2*

CWT facilities that discharge process wastewater directly to a receiving stream or indirectly to a POTW will have monitoring costs. EPA regulations require both direct discharge with NPDES permits and indirect dischargers subject to categorical pretreatment standards to monitor their effluent.

EPA used the following generalizations to estimate the CWT monitoring costs:

1. EPA included analytical cost for parameters at each subcategory as follows:
   - TSS, O&G, Cr+6, total CN, and full metals analyses for the metals subcategory direct dischargers, and Cr+6, total CN, and full metals analyses for the metals subcategory indirect dischargers;
   - TSS, O&G, and full metals and semi-volatiles analyses for the oils subcategory option 8 and 9 direct dischargers, and full metals, and semi-volatiles for oils subcategory options 8 and 9 indirect dischargers;
   - TSS, O&G, and full metals, volatiles and semi-volatiles analyses for the oils subcategory direct dischargers, and full metals, volatiles, and semi-volatiles for oils subcategory option 8V and 9V indirect dischargers;
   - TSS, BOD_5, O&G, 6 individual metals, volatiles, and semi-volatiles analyses for the organics subcategory option 3 direct dischargers, and 6 individual metals, volatiles, and semi-volatiles analyses for the organics subcategory option 3 indirect dischargers; and
   - TSS, BOD_5, O&G, 6 individual metals, and semi-volatiles analyses for the organics subcategory option 4 direct dischargers, and 6 individual metals and semi-volatiles analyses for the organics subcategory option 4 indirect dischargers.

   EPA notes that these analytical costs may be overstated for the oils and the organics subcategories because EPA's final list of regulated pollutants for these subcategories do not include all of the parameters included above.

2. The monitoring frequencies are listed in Table 11-21 and are as follows:

Table 11-21. Monitoring Frequency Requirements

Parameter	Monitoring Frequency (samples/month)		
	Metals Subcategory	Oils Subcategory	Organics Subcategory
Conventionals*	20	20	20
Total Cyanide and Cr+6	20	-	-
Metals	20	4	4
Semi-Volatile Organics	-	4	4
Volatile Organics	-	4**	4**

*Conventional monitoring for direct dischargers only.
**Volatile organics monitoring for oils option 8V and 9V and organics option 3 only.

3. For facilities in multiple subcategories, EPA applied full multiple, subcategory-specific monitoring costs.
4. EPA based the monitoring costs on the number of outfalls through which process wastewater is discharged. EPA multiplied

the cost for a single outfall by the number of outfalls to arrive at the total costs for a facility. For facilities for which this information is not available, EPA assumed a single outfall per facility.

5. EPA did not base monitoring costs on flow rate.

6. EPA did not include sample collection costs (labor and equipment) and sample shipping costs, and

7. The monitoring cost (based on frequency and analytical methods) are incremental to the monitoring currently being incurred by the CWT Industry. EPA applied credit to facilities for current monitoring-in-place (MIP). For facilities where actual monitoring frequencies are unknown, EPA estimated monitoring frequencies based on other subcategory facilities with known monitoring frequencies.

Table 11-22 shows the cost of the analyses needed to determine compliance for the CWT pollutants. EPA obtained these costs from actual quotes given by vendors and converted to 1989 dollars using the ENR's Construction Cost Index.

Table 11-22. Analytical Cost Estimates

Analyses	Cost ($1989)
BOD_5	$20
TSS	$10
O&G	$32
Cr+6	$20
Total CN	$30
Metals:	$335
Total (27 Metals)	$335
Per Metal[1]	$35
Volatile Organics (method 1624)[2]	$285
Semi-volatile Organics (method 1625)[2]	$615

[1]For 10 or more metals, use the full metals analysis cost of $335.

[2]There is no incremental cost per compound for methods 1624 and 1625 (although there may be a slight savings if the entire scan does not have to be reported). Use the full method cost, regardless of the actual number of constituent parameters required.

Land Costs 11.5.3

An important factor in the calculation of treatment technology costs is the value of the land needed for the installation of the technology. To determine the amount of land required for costing purposes, EPA calculated the land requirements for each treatment technology for the range of system sizes. EPA fit these land requirements to a curve and calculated land requirements, in acres, for every treatment system costed. EPA then multiplied the individual land requirements by the corresponding state land cost estimates to obtain facility-specific cost estimates.

EPA used different land cost estimates for each state rather than a single nationwide average since land costs may vary widely across the country. To estimate land costs for each state, EPA obtained average land costs for suburban sites for each state from the 1990 Guide to Industrial and Real Estate Office Markets survey. EPA based these land costs on "unimproved sites" since, according to the survey, they are the most desirable.

The survey additionally provides land costs broken down by size ranges. These are zero to 10 acres, 10 to 100 acres, and greater than 100 acres. Because CWT facilities fall into all three size ranges (based on responses to the WTI Questionnaire), EPA averaged the three size-specific land costs for each state to arrive at the final land costs for each state.

The survey did not provide land cost estimates for Alaska, Idaho, Montana, North Dakota, Rhode Island, South Dakota, Utah, Vermont or West Virginia. For these states, EPA used regional averages of land costs. EPA determined the states comprising each region also based on the aforementioned survey since the survey categorizes the states by geographical region (northeast, north central, south, and west). In estimating the regional average costs for the western region, EPA did not include Hawaii since Hawaii's land cost is high and would have skewed the regional average.

Table 11-23 lists the land cost per acre for each state. As Table 11-23 indicates, the least expensive state is Kansas with a land cost of $7,042 per acre and the most expensive state is Hawaii with a land cost of $1,089,000 per acre.

Table 11-23. State Land Costs for the CWT Industry Cost Exercise

State	Land Cost per Acre (1989 $)	State	Land Cost per Acre (1989 $)
Alabama	0.00	Nebraska	24,684
Alaska*	0.00	Nevada	36,300
Arizona	0.00	New Hampshire	52,998
Arkansas	0.00	New Jersey	89,443
California	0.00	New Mexico	26,929
Colorado	0.00	New York	110,013
Connecticut	0.00	North Carolina	33,880
Delaware	0.00	North Dakota*	20,488
Florida	0.00	Ohio	14,578
Georgia	0.00	Oklahoma	24,321
Hawaii	1,089,000	Oregon	50,820
Idaho*	81,105	Pennsylvania	32,307
Illinois	36,300	Rhode Island*	59,822
Indiana	21,078	South Carolina	21,296
Iowa	8,954	South Dakota*	20,488
Kansas	7,042	Tennessee	20,873
Kentucky	29,040	Texas	47,674
Louisiana	56,628	Utah*	81,105
Maine	19,602	Vermont*	59,822
Maryland	112,530	Virginia	39,930
Massachusetts	59,895	Washington	63,670
Michigan	13,649	West Virginia*	47,345
Minnesota	21,054	Wisconsin	17,424
Mississippi	13,068	Wyoming*	81,105
Missouri	39,930	Washington DC	174,240
Montana*	81,105		

* No data available for state, used regional average.

EXAMPLE 11-1:

Costing exercise for direct discharging metals subcategory facility with treatment in-place.

Example Facility Information:

Current Treatment In-Place:
Primary Chemical Precipitation + Clarification + Plate and Frame Sludge Filtration

Daily Flow = 0.12196 MGD (Million Gallons/Day)
[NOTE: Daily Flow = X in costing equations]

Treatment Upgrades To Be Costed:
Primary Chemical Precipitation Upgrade + Clarifier Upgrade + Sludge Filtration Upgrade

Full Treatment Technologies To Be Costed:
Secondary Chemical Precipitation + Secondary Clarification + Multimedia Filtration

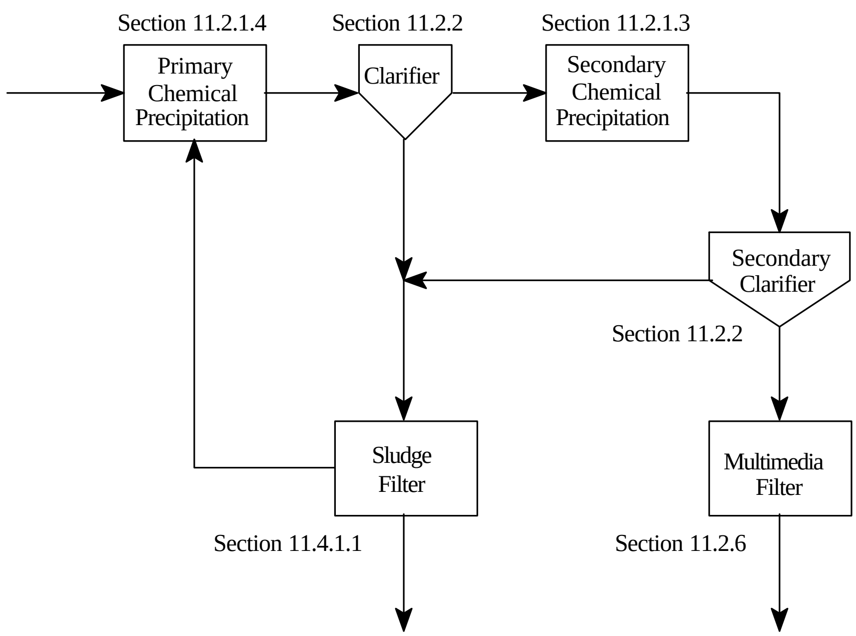

Figure 11-1. Metals Option 4 Model Facility Diagram

EXAMPLE 11-1, CONTINUED:

Capital Costs:

C Primary chemical precipitation *upgrade*, from Table 11-7, Section 11.2.1.4.
The maximum size holding tank to be costed for a primary chemical precip. *upgrade* is 0.005 MGD. In addition, there is a 20% retrofit cost for the *upgrade*.

ln(Y1) = 10.671 - 0.083*ln(X) - 0.032*$(\ln(X))^2$
= 10.671 - 0.083*ln(0.005) - 0.032*$(\ln(0.005))^2$
= 10.212
ˆ Y1 = $27,240.25 * 1.2 = $32,688.30 –

C Clarification capital cost *upgrade*, following primary precipitation = $0.00 –

C Sludge filtration capital cost *upgrade* = $0.00 –

C Secondary chemical precipitation, full capital costs, from Table 11-8, Section 11.2.1.5

ln(Y1) = 13.829 + 0.544*ln(X) + 4.96E-6*$(\ln(X))^2$
= 12.68441
ˆ Y1 = $322,678.63 –

C Clarification, following secondary chemical precipitation, from Table 11-9, Section 11.2.2.2

ln(Y1) = 11.552 + 0.409*ln(X) + 0.020*$(\ln(X))^2$
= 10.77998
ˆ Y1 = $48,049.17 –

C Multi-media filtration capital costs, from Table 11-13, Section 11.2.5

ln(Y1) = 12.0126 + 0.48025*ln(X) + 0.04623*$(\ln(X))^2$
= 11.20679
ˆ Y1 = $73,628.54 –

C Total capital cost (TCC)

TCC = 3 (Individual Capital Costs)
ˆ TCC = **$477,045** €

EXAMPLE 11-1, CONTINUED:

Operation and Maintenance Costs:

C Primary chemical precipitation O&M *upgrade*, from Table 11-7, Section 11.2.1.4

ln(Y2) = 11.6203 + 1.05998*ln(X) + 0.04602*(ln(X))^2
= 11.6203 + 1.05998*ln(0.12196) + 0.04602*(ln(0.12196))^2
= 9.59377

ˆ Y2 = $14,673.09 –

C Clarification O&M *upgrade*, following primary chemical precipitation, from Table 11-9, Section 11.2.2

ln(Y2) = 6.81347 + 0.33149*ln(X) + 0.0242*(ln(X))^2
= 6.22313

ˆ Y2 = $504.28 –

C Sludge filtration O&M *upgrade*, from Table 11-19, Section 11.4.1

ln(Y2) = 12.014 + 1.17846*ln(X) + 0.05026*(ln(X))^2
= 9.75695

ˆ Y2 = $17,273.90 – (which includes filter cake disposal costs)

C Secondary chemical precipitation O&M costs, from Table 11-8, Section 11.2.1.5

ln(Y2) = 12.076 + 0.63456*ln(X) + 0.03678*(ln(X))^2
= 10.9037

ˆ Y2 = $54,375.79 –

C Clarification O&M costs, following secondary chemical precipitation, from Table 11-9, Section 11.2.2.2

ln(Y2) = 10.673 + 0.238*ln(X) + 0.013*(ln(X))^2
= 10.22979

ˆ Y2 = $27,716.56 –

C Multimedia Filtration O&M Costs, from Table 11-13, Section 11.2.5

ln(Y2) = 11.5039 + 0.72458*ln(X) + 0.09535*(ln(X))^2
= 10.40146

ˆ Y2 = $32,907.65 –

C Total Operation and Maintenance Cost ($O\&M_{Tot}$)

$O\&M_{Tot}$ = 3 (Individual O& M Costs)

ˆ $O\&M_{Tot}$ = **$147,453** €

EXAMPLE 11-1, CONTINUED:

Land Requirements:

C Primary chemical precipitation *upgrade* land requirement associated with capital cost upgrade (Table 11-7, section 11.2.1.4). The maximum size holding tank to be costed for a primary chemical precipitation *upgrade* is 0.005 MGD.

$$\begin{aligned} \ln(Y3) &= -2.866 - 0.023\ln(X) - 0.006(\ln(X))^2 \\ &= -2.866 - 0.023\ln(0.005) - 0.006(\ln(0.005))^2 \\ &= -2.913 \end{aligned}$$

ˆ $Y3 = 0.054$ acre –

C Clarifier, following primary chemical precipitation, land requirement = 0.0 acre –

C Sludge filtration unit land requirement = 0.0 acre –

C Secondary chemical precipitation land requirement, from Table 11-8, Section 11.2.1.5

$$\begin{aligned} \ln(Y3) &= -1.15 + 0.449*\ln(X) + 0.027*(\ln(X))^2 \\ &= -1.975 \end{aligned}$$

ˆ $Y3 = 0.139$ acre –

C Clarification, following secondary chemical precipitation, land requirement, from Table 11-9, Section 11.2.2.2

$$\begin{aligned} \ln(Y3) &= -1.773 + 0.513*\ln(X) + 0.046*(\ln(X))^2 \\ &= -2.6487 \end{aligned}$$

ˆ $Y3 = 0.071$ acre –

C Multimedia filtration land requirement, from Table 11-13, Section 11.2.5

$$\begin{aligned} \ln(Y3) &= -2.6569 + 0.1937*\ln(X) + 0.02496*(\ln(X))^2 \\ &= -2.95396 \end{aligned}$$

ˆ $Y3 = 0.0521$ acre –

C Total land requirement (TLR)

TLR = 3 (Individual Land Requirement)

ˆ TLR = **0.316 acre €**

EXAMPLE 11-2:

Costing exercise for a direct discharging oils subcategory facility with only emulsion breaking/gravity separation in-place.

Example Facility Information:

Current Treatment In-Place:
Primary Emulsion Breaking/Gravity Separation
Daily Flow = 0.0081 MGD (Million Gallons/Day) [= 5.63 gpm]
[NOTE: Daily Flow = X in costing equations]

Treatment Upgrades To Be Costed:
None

Full Treatment Technologies To Be Costed:
Secondary Gravity Separation + Dissolved Air Flotation (DAF)

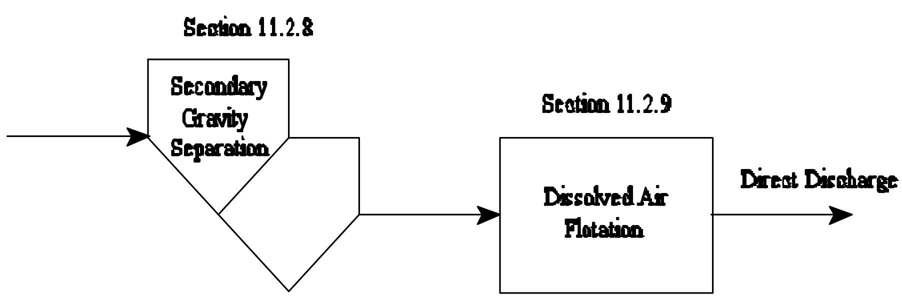

Figure 11-2. Treatment Diagram For Oils Option 9 Facility Improvements

EXAMPLE 11-2, CONTINUED:

Capital Costs:

C Secondary gravity separation, from Table 11-15, Section 11.2.7

$\ln(Y1) = 14.3209 + 0.38774*\ln(X) - 0.01793*(\ln(X))^2$
$= 14.3209 - 0.38774*\ln(0.0081) - 0.01793*(\ln(0.0081))^2$
$= 12.0377$

ˆ Y1 = $169,014.42 –

C Dissolved air flotation costs, from Table 11-17, Section 11.2.8

$\ln(Y1) = 13.9518 + 0.29445*\ln(X) - 0.12049*(\ln(X))^2$
$= 11.6415$

ˆ Y1 = $113,720.41 –

C Holding tank for dissolved air flotation (flow < 20 gpm, hence holding tank is sized), from Table 11-17, Section 11.2.8

$\ln(Y1) = 12.5122 - 0.15500*\ln(X) - 0.05618*(\ln(X))^2$
$= 11.9557$

ˆ Y1 = $155,700.75 –

C Total capital cost (TCC)

TCC = 3 (Individual Capital Costs)

ˆ TCC = **$438,436** €

EXAMPLE 11-2, CONTINUED:

Operation and Maintenance Costs:

C Secondary gravity separation, from Table 11-15, Section 11.2.7

$\ln(Y2) = 12.0759 + 0.4401{*}\ln(X) + 0.01594{*}(\ln(X))^2$

$= 12.0759 + 0.4401{*}\ln(0.0081) + 0.01594{*}(\ln(0.0081))^2$

$= 10.3261$

ˆ Y2 = $30,519.46 –

C Dissolved air flotation (flow < 20 gpm), from Table 11-17, Section 11.2.8

$\ln(Y2) = 21.2446 + 4.14823{*}\ln(X) + 0.36585{*}(\ln(X))^2$

$= 9.7523$

ˆ Y2 = $17,193.12 –

C Total Operation and Maintenance Cost ($O\&M_{Tot}$)

$O\&M_{Tot}$ = 3 (Individual O& M Costs)

ˆ $O\&M_{Tot}$ = **$47,713** €

EXAMPLE 11-2, CONTINUED:

Land Requirements:

C Secondary gravity separation, Table 11-15, Section 11.2.7

$$\ln(Y3) = -0.2869 + 0.31387*\ln(X) + 0.01191*(\ln(X))^2$$
$$= -0.2869 + 0.31387*\ln(0.0081) + 0.01191*(\ln(0.0081))^2$$
$$= -1.5222$$

ˆ Y3 = 0.218 acre –

C Dissolved air flotation (sized at 25 gpm, the minimum available), from Table 11-17, Section 11.2.8

$$\ln(Y3) = -0.5107 + 0.51217*\ln(X) - 0.01892*(\ln(X))^2$$
$$= -2.4224$$

ˆ Y3 = 0.089 acre –

C Holding tank, from Table 11-17, Section 11.2.8

$$\ln(Y3) = -1.5772 + 0.35955*\ln(X) + 0.02013*(\ln(X))^2$$
$$= -1.5012$$

ˆ Y3 = 0.223 acre –

C Total land requirement (TLR)

TLR = 3 (Individual Land Requirement)

ˆ TLR = **0.53 acre €**

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SUMMARY OF COST OF TECHNOLOGY OPTIONS *11.7*

This section summarizes the estimated capital and annual O&M expenditures for CWT facilities to achieve each of the effluent limitations and standards. All cost estimates in this section are expressed in terms of 1997 dollars.

BPT Costs *11.7.1*

BPT costs apply to all CWT facilities that discharge wastewater to surface waters (direct dischargers). Table 11-24 summarizes, by subcategory, the total capital expenditures and annual O&M costs for implementing BPT.

Table 11-24. Cost of Implementing BPT Regulations [in 1997 dollars]

Subcategory	Number of Facilities[1]	Total Capital Costs	Annual O&M Costs
Metals Treatment and Recovery	9	4,069,600	3,103,200
Oils Treatment and Recovery	5	1,168,100	432,100
Organics Treatment	4	80,000	215,800
Multiple Wastestream Subcategory[2]	3	1,836,200	3,618,300
Combined Regulatory Option[3]	14	5,317,700	3,751,100

[1] There are 14 direct dischargers. Because some direct dischargers include operations in more than one subcategory, the sum of the facilities with operations in any one subcategory exceeds the total number of facilities.
[2] This estimate assumes that all facilities that accept waste in multiple subcategories elect to comply with the single Subcategory limitations.
[3] This total assumes that all facilities that accept waste in multiple subcategories elect to comply with each set of limitations separately.

EPA notes that this BPT cost summary does not include the additional capital costs of the second clarifier that may be associated with the transferred TSS limitations for the metals subcategory. EPA will re-visit its BPT costs estimates for this subcategory prior to promulgation.

BCT/BAT Costs *11.7.2*

The Agency estimated that there would be no incremental cost of compliance for implementing BCT/BAT, because the technology used to develop BCT/BAT limitations is identical to BPT and the costs are included with BPT.

PSES Costs *11.7.3*

The Agency estimated the cost for implementing PSES applying the same assumptions and methodology used to estimate cost of implementing BPT. The major difference is that the PSES costs are applied to all CWT facilities that discharge wastewater to a POTW (indirect dischargers). Table 11-25 summarizes, by subcategory, the capital expenditures and annual O&M costs for implementing PSES.

Table 11-25. Cost of Implementing PSES Regulations [in 1997 dollars]

Subcategory	Number of Facilities[1]	Total Capital Costs	Annual O&M Costs
Metals Treatment and Recovery	44	11,111,100	10,242,100
Oils Treatment and Recovery -	127	23,834,000	12,484,400
Organics Treatment	16	17,709,200	2,766,200
Mutliple Wastestream Subcategory[2]	24	44,576,100	20,392,700
Combined Regulatory Option[3]	151	52,654,300	25,792,700

[1] There are 151 indirect dischargers. Because some indirect dischargers include operations in more than one subcategory, the sum of the facilities with operations in any one subcategory exceeds the total number of facilities.

[2] This estimate assumes that all facilities that accept waste in multiple subcategories elect to comply with the single Subcategory limitations.

[3] This total assumes that all facilities that accept waste in multiple subcategories elect to comply with each set of limitations separately.